Sound:

- Pitch → perceived frequency
- Loudness → intensity of the sound
- Intensity calculated by:

$$I = \frac{P}{4\pi r^2}$$

P → power; $4\pi r^2$ → surface area of sphere; r → distance from source; I → intensity

measured in W/m^2

- Absolute scale of loudness is measured in W/m^2, but relative scale is measured in decibels (dB).

$\emptyset$ dB = $1E-12$ W/m^2 — threshold of human hearing

10 dB = $1E-11$ W/m^2

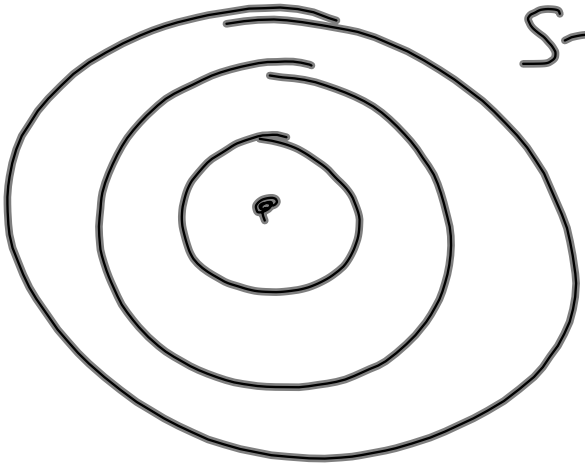
60 dB = $1E-6$ W/m^2

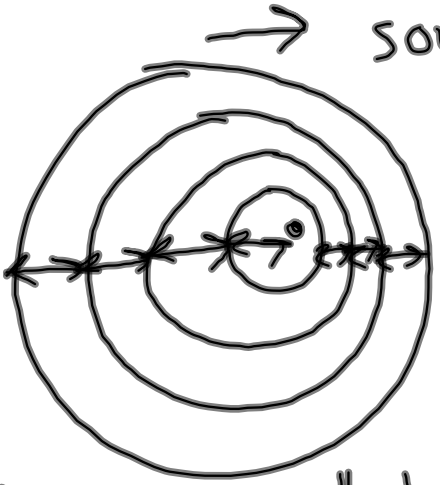
120 dB = $1E\emptyset$ W/m^2 — threshold of pain

- Speed of sound depends on the medium

solids > liquids > gases

- Doppler Effect



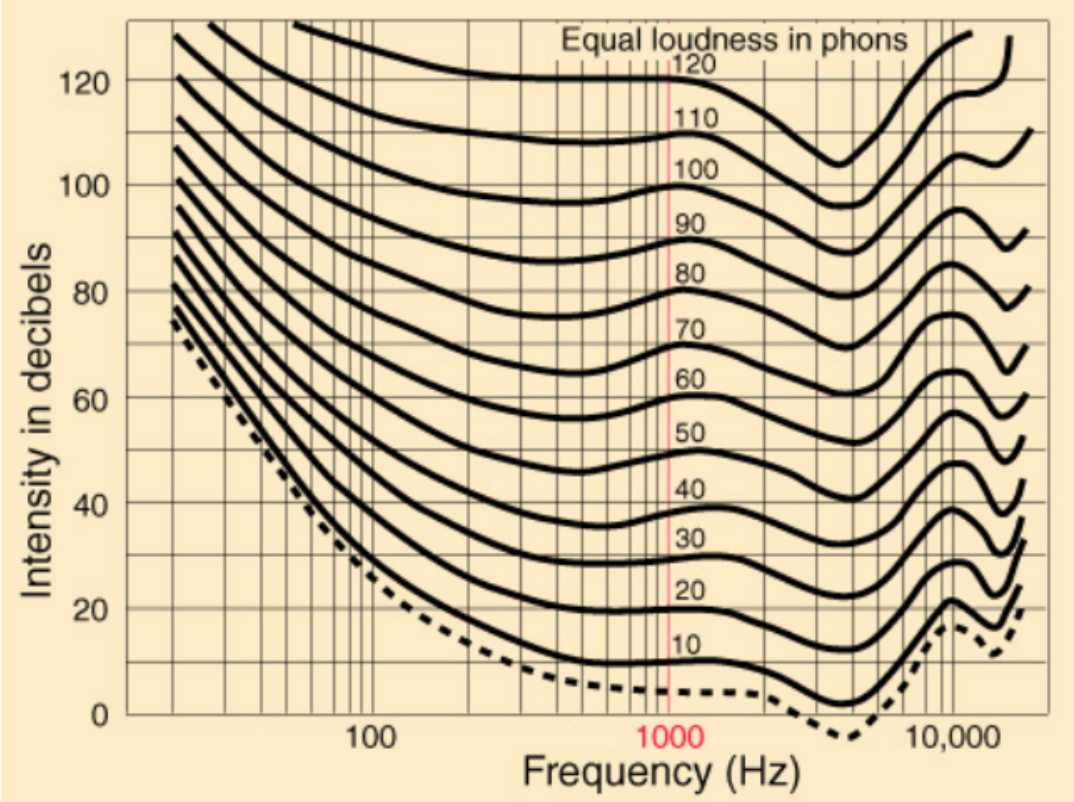


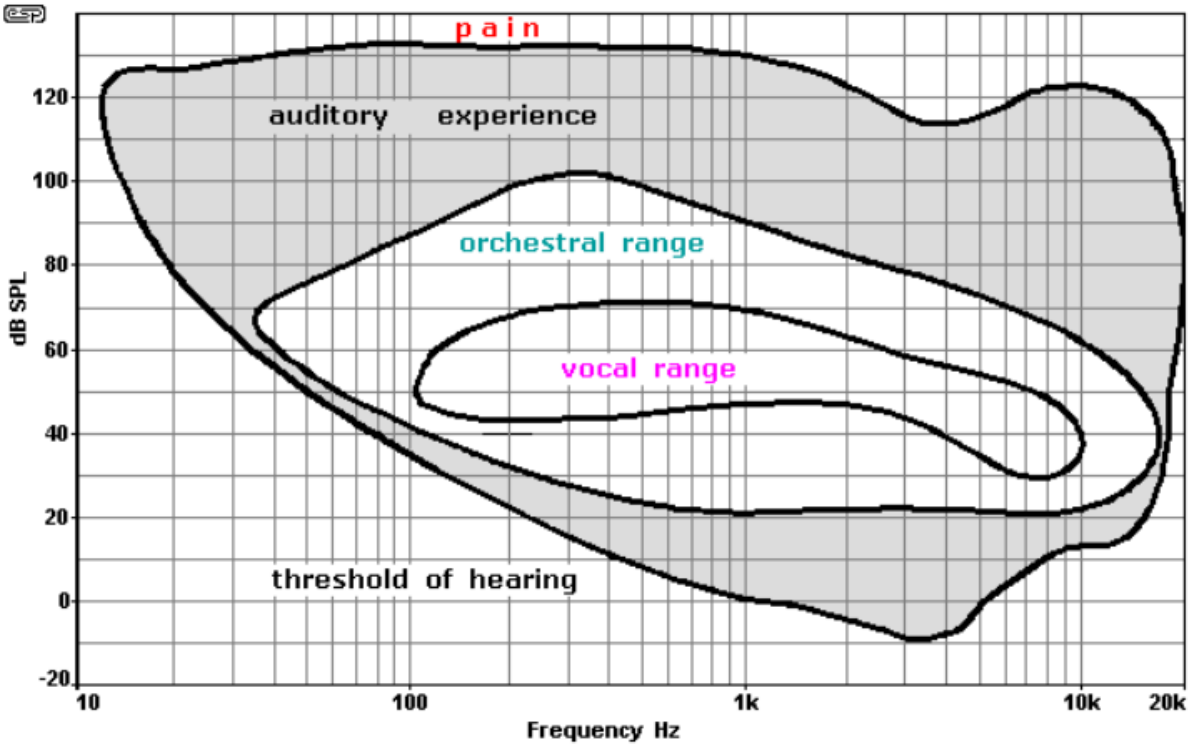
$$V = f\lambda$$

$$f = \frac{V}{\lambda}$$

λ longer λ shorter

lower f higher f


Equal loudness in phons
120
110
100
90
80
70
60
50
40
30
20
10
Intensity in decibels
120
100
80
60
40
20
0
100
1000
10,000
Frequency (Hz)


pain
auditory experience
orchestral range
vocal range
threshold of hearing
dB SPL
120
100
80
60
40
20
0
-20
10
100
1k
10k
20k
Frequency Hz